

Appl. No. 10/065,296
Amdt. dated 11/25/2004
Reply to Office action of 08/25/2004

REMARKS/ARGUMENTS

1. Request for Continued Examination:

5 The Applicant respectfully requests continued examination of the above-indicated application as per 37 CFR 1.114.

2. Response to the objection to the drawings:

10 The drawings are objected to as failing to comply with 37 CFR 1.84(p)(4) because reference character "20" has been used to designate both N-type doped region and some other region in prior art Fig. 1.

15 The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they do not include the following reference sign(s) mentioned in the description: 10 in prior art Fig. 1.

20 Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are 25 not accepted by the examiner, the applicant will be notified and informed

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of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Response:

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The prior art Fig. 1 is amended to overcome this objection and to put the present application in condition for allowance. In the amended prior art Fig. 1, the reference number "20" is referring to the N-type doped region mentioned in the specification, and the previously omitted 10 reference number "10" is introduced to refer to the semiconductor wafer mentioned in the specification. No new material has been introduced by these amendments. Reconsideration of the corrected drawings is hereby requested.

15 **3. Response to the objection to the specification:**

The disclosure is objected to because of the following informalities: Paragraph [0019] is inaccurate. Lower implantation energies give smaller penetration into the substrate than higher implantation steps. Accordingly 20 it is inaccurate to state,

"Noticeably, the implantation energy of the first ion implantation process should be smaller than that of the second ion implantation process, so that the junction depth produced by the doped region 46 and the P-type epitaxial layer 34 is smaller than the junction depth produced by the 25 second region 42 and the P-type epitaxial layer 34."

Fig. 4 shows that the junction depth of 46 is smaller than that of 42

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indicating that the first ion implantation energy used to form 42 is necessarily greater --not smaller-- than the implantation energy used to form 46.

5 Appropriated correction is required.

Response:

10 Paragraph [0019] is corrected as suggested by the Examiner. The inaccurate statement is appropriately corrected to correspond to Fig. 4. Reconsideration of the corrected specification is hereby requested.

4. Response to the rejection of claims 1-4, 6, 8-10 under 35 U.S.C. 102(b):

15 Claims 1-4, 6, 8-10 are rejected under 35 U.S.C. 102(b) as being anticipated by US 4,415,370 (Kagawa et al.).

20 Regarding claim 1, Kagawa discloses a method of forming a photo sensor in a photo diode formed on a semiconductor wafer, a surface of the semiconductor comprising a substrate with first-type dopants, and an insulating layer positioned on the surface of the substrate and surrounding the photo sensor, the method comprising:

25 forming a first mask layer 22 on the surface of the substrate 21 for defining positions of a plurality of first doped regions 23 in the photo sensor (Fig. 6B);

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performing a first ion implantation process utilizing second-type dopants to form the plurality of first doped regions on the surface of the photo sensor (Fig. 6B);

5 removing the first mask layer and forming a second mask layer 22 surrounding the photo sensor (Fig. 6C); and

performing a second ion implantation process utilizing second-type dopants to form a second doped region on the surface of the photo sensor, and the second doped region being overlapped with a partial region of each of the first doped regions (Fig. 6C). See col. 7, line 31 to col. 8, line 10 11.

Regarding claim 2, the method of claim 1 wherein the dopants in the first doped regions and in the second doped region interact with neighboring substrate to form a plurality of depletion regions (Figs. 5G, 15 6E).

Regarding claim 3, the method of claim 1 wherein the first-type dopants are N-type, and the second-type dopants are P-type (Figs. 6A-6F).

20 Regarding claim 4, the method of claim 1 wherein the first-type dopants are P-type, and the second-type dopants are N-type (Figs. 7A-7G; col. 8, lines 23-59).

25 Regarding claim 6, the method of claim 1 wherein a dopant density of the first ion implantation process is less than a dopant density of the second ion implantation process (Figs. 4A-4B).

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Regarding claim 8, the method of claim 1 wherein the method further comprises an annealing process for driving-in the dopants in the second doped region (col. 7, lines 45-47).

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Regarding claim 9, the method of claim 1 wherein each of the depletion regions formed between the neighboring first doped regions is inherently a complete depletion region, and a capacitance of each of the depletion regions is approximately equal to zero for increasing a sensing area, decreasing dark current, and further increasing photo current and photon conversion gain as admitted by Applicant in the instant specification because the Kagawa structure is the same structure as presently claimed. (See MPEP 2112)

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Regarding claim 10, the method of claim 1 wherein the second doped region 24 is capable of being utilized as a conducting wire of the photo sensor.

Response:

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First, claim 1 is amended in the above AMENDMENTS TO THE CLAIMS section to make the limitation more clear. Claim 1 is amended according to Figs. 3-6 and paragraph [0021] of the present application. No new matter is introduced.

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Second, the Applicant intends to point out the difference between the

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amended claim 1 of the present application and Kagawa's disclosure. The amended claim 1 of the present application is repeated below:

5 **Claim 1 (currently amended): A method of forming a photo sensor in a photo diode formed on a semiconductor wafer, a surface of the semiconductor wafer comprising a substrate with first-type dopants, and an insulating layer positioned on the surface of the substrate and surrounding the photo sensor, the method comprising:**

10 **forming a first mask layer on the surface of the substrate for defining positions of *a plurality of first doped regions distributed in the photo sensor;***

15 **performing a first ion implantation process utilizing second-type dopants to *form the plurality of first doped regions for increasing a contacting area between each first doped region and the substrate so as to increase a sensing area of the photo sensor;***

20 **removing the first mask layer and forming a second mask layer surrounding the photo sensor; and**

25 **performing a second ion implantation process utilizing second-type dopants to form a second doped region on the surface of the photo sensor, and the second doped region being overlapped with a partial region of each of the first doped regions.**

As disclosed in the amended claim 1, the plurality of first doped regions are distributed in the photo sensor so as to increase a contacting area between each first doped region and the substrate to increase a sensing area of the photo sensor. Kagawa teaches to perform a first

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implantation process to form p-type guard ring regions 23, and perform a second implantation process to form a p-type layer 24 in a photo sensor (Figs. 6C-6E, col. 7, lines 33-45). The Examiner reads the p-type guard ring regions 23 as the first doped regions of the present application.

5 However, the p-type guard ring regions 23 are limited to being formed "surrounding the photo sensor" for the purposes to increase the breakdown voltage at the periphery of the p-type layer 24 and to lower noise (col. 6, lines 50-53, col. 7, line 64 – col. 8, line 11). Since Kagawa never teaches that the p-type guard ring regions 23 can be "distributed in the photo 10 sensor", it is believed that the guard ring regions taught by Kagawa cannot be read as the first doped regions disclosed in the amended claim 1 of the present invention to provide the advantages of increasing a contacting area between each first doped and the substrate and increasing a sensing area of the photo sensor.

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From the aforementioned reasons, the Applicant believes that the amended claim 1 of the present application is absolutely different from Kagawa's disclosure. Reconsideration of the amended claim 1 is politely requested.

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As claims 2-4, 6, and 8-10 are dependent upon the amended claim 1, they should be allowed if the amended claim 1 is allowed. Reconsideration of claims 2-4, 6, and 8-10 is therefore requested.

25 **5. Response to the rejection of claims 1-5, and 8-10 under 35 U.S.C. 103(a):**

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Claims 1-5, and 8-10 are rejected under 35 U.S.C. 103(a) as being unpatentable over US 5,767,538 (Mullins et al.) in view of Van Zant, Microchip Fabrication, 4th ed. McGraw-Hill: New York, 2000, pp. 72-74.

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Regarding claim 1, Mullins discloses a method of forming a photo sensor 5 (Fig. 3A) in a photo diode 5 formed on a semiconductor wafer 50, a surface of the semiconductor comprising a substrate with first-type dopants, and an insulating layer positioned on the surface of the substrate 10 and surrounding the photo sensor 5, the method comprising:

performing a first ion implantation process utilizing second-type dopants to form the plurality of first doped regions 47 on the surface of the photo sensor 5;

15 performing a second ion implantation process utilizing second-type dopants to form a second doped region 46 on the surface of the photo sensor 5, and the second doped region being overlapped with a partial region of each of the first doped regions (Fig. 3A; col. 8, line 66 to col. 9, line 26).

20 Mullins does not teach that first and second masks are used to perform the first and second implantations to form the separate doped regions 46 and 47.

25 Van Zant teaches that it is essential to use a patterned mask having windows formed over regions of the substrate in which ions are to be implanted while blocking the remaining regions in which no ions are to be

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implanted.

It would have been obvious for one of ordinary skill in the art, at the time of the invention to use first and second masks in Mullins to implant 5 the separate areas 46 and 47 because the regions has different profiles and therefore require separate implantation steps, as taught by Van Zant to be essential.

Regarding claim 2, Mullins discloses the method of claim 1 wherein 10 the dopants in the first doped regions and in the second doped region interact with neighboring substrate to form a plurality of depletion regions (Fig. 3A).

Regarding claim 3, Mullins discloses the method of claim 1 wherein 15 the first-type dopants are N-type, and the second-type dopants are P-type (Fig. 3A).

Regarding claim 4, Mullins discloses the method of claim 1 wherein the first-type dopants are P-type, and the second-type dopants are N-type 20 (col. 11, lines 7-10).

Regarding claim 5, Mullins discloses the method of claim 1 wherein the substrate further comprises an epitaxial silicon layer, and each of the first doped regions and the second region are formed inside the epitaxial 25 silicon layer (col. 4, lines 30-33).

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Regarding claim 8, Mullins discloses the method of claim 1 wherein the method further comprises an annealing process for driving-in the dopants in the second doped region.

5 Regarding claim 9, Mullins discloses the method of claim 1 wherein each of the depletion regions formed between the neighboring first doped regions is inherently a complete depletion region, and a capacitance of each of the depletion regions is approximately equal to zero for increasing a sensing area, decreasing dark current, and further increasing photo 10 current and photon conversion gain as admitted by Applicant in the instant specification because the Mullins structure is the same structure as presently claimed. (See MPEP 2112)

15 Regarding claim 10, the method of claim 1 wherein the second doped region is utilized to be a conducting wire of the photo sensor (Fig. 3A).

Response:

20 Claim 1 is amended to emphasize the outstanding feature of the present invention and to overcome this rejection. As disclosed in the amended claim 1, the plurality of first doped regions are "distributed in the photo sensor" so as to increase a contacting area between each first doped region and the substrate to increase a sensing area of the photo sensor.

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Mullins discloses a circuit, a photo sensor structure and operation

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methods thereof. The photo sensor includes p-type contact diffusions 47 overlapped with a shallow p-type ion implanted region 46 (Fig. 3A, col. 9, lines 1-10). Mullins never teaches method steps such as forming the first mask layer and the second mask layer, and performing the first ion implantation process and the second ion implantation process as are disclosed in the amended claim 1 of the present application. Van Zant teaches essential concepts of an ion implantation process, including forming a patterned mask layer. However, Van Zant does not teach the method steps to form a photo sensor, such as forming the first mask layer and the second mask layer, and performing the first ion implantation process and the second ion implantation process as are disclosed in the amended claim 1 of the present application. Since neither Mullins nor Van Zant teaches the method steps disclosed in the amended claim 1, the Applicant respectfully believes that one of ordinary skill cannot combine the disclosures of Mullins and Van Zant to accomplish the present application.

In addition, Mullins uses the p-type contact diffusions 47, which the Examiner reads as the first doped regions of the present application, as a connecting wire of the photo sensor to provide coupling of the P+ anode to the ground or the input of transimpedance amplifier 2 (col. 9, lines 7-10). However, the first doped regions of the present application are distributed in the photo sensor so as to increase a contacting area between each first doped region and the substrate to increase a sensing area of the photo sensor. Claim 10 of the present application discloses that the second doped region, instead of the first doped regions, is utilized to be a

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conducting wire of the photo sensor. Because both the function of the first doped regions and the operation method of the photo diode of the present application are different from Mullins' disclosure, it is believed that the photo diode structure taught by Mullins is still different from the present application.

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From the aforementioned reasons, the Applicant believes that the amended claim 1 of the present application cannot be obtained from the combination of Mullins and Van Zant. Reconsideration of the amended 10 claim 1 is politely requested.

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As claims 2-5, and 8-10 are dependent upon the amended claim 1, they should be allowed if the amended claim 1 is allowed. Reconsideration of claims 2-5 and 8-10 is therefore requested.

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6. Introduction to new claims 20 and 21:

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Claim 20 is introduced to further limit the present invention method disclosed in the amended claim 1. The features introduced in the new claim 20 are disclosed in Figs. 3-5 and paragraph [0020] of the present application. No new matter is introduced. As claim 20 is dependent upon the amended claim 1, it should be allowed if the amended claim 1 is allowed.

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Claim 21 is introduced by merging the original claim 1 and the allowable subject matter disclosed in claim 7. No new matter is introduced.

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Allowance of claim 21 is politely requested.

Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

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Sincerely yours,

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Attachments

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